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BIOLOGICAL STUDIES OF TWO HYMENOPTEROUS PARASITES OF AQUATIC INSECT EGGS

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The material and a part of the data for the following studies were gathered at the Biological Station of the University of Michigan, which is located on Douglas Lake, Michigan. The lake is situated in the upper part of the lower peninsula of Michigan, about fifteen miles south of the Straits of Mackinac. On the older maps of the locality this lake was called Turtle Lake. The region is of recent glacial origin, lying at the southern edge of the Boreal Life Zone. Sandy moraines cover the area which is a cut-over pine district. A few pines still stand, but the aspen association is the prominent one of the uplands. The region abounds with numerous bogs and swamps in various stages of development. The lake itself is said to resemble a fish in outline with the tail toward the southeast. The main axis of the lake is a little over four miles in length and takes nearly the same direction as that of the prevailing winds which are from the northwest nine months of the year. The shores are of fine white sand and with a considerable growth of *Scirpus* along sheltered places. At one point the *Scirpus* extends into the lake, going almost across. At this particular place the water is not over eight feet in depth.

The *Scirpus* offered an excellent place for *Sialis infumata* Newm., *Chrysops striatus* O. S., *Chrysops excitans* Walk., and some *Tabanus* to deposit their eggs. It was the finding of parasites on *Chryosps* egg masses by Dr. H. B. Hungerford that later led the author to work on the life history of this parasite. The work was done under his direction. While working on this life history, eggs of other aquatic insects were also collected, which led to the finding of the gerrid egg parasite, *Tiphodytes gerriphagus* (Marchal). This parasite has been reported only once before in America. Matheson and Crosby[22] found it parasitizing gerrid eggs at Ithaca, New York, in 1912.

Several other such egg parasites should be found in this region. The following are some reported from New York: *Prestwichia aquatica* Lubb., parasitic on the eggs of *Ranatra, Dytiscus, Agabus,* *Notonecta,* dragon-flies and others; *Cataphractus cinctus* Walker, parasitic on the eggs of Notonectidae; *Hydrophylax aquivolans* Matheson and Crosby, parasitic on the eggs of *Ischnura.*

In addition to working on the life histories of the above-mentioned parasites it was possible to obtain some valuable and interesting notes on the egg-laying habits and on the copulation of *Sialis infumata* Newm., which was so common along the shores of the lake at the beginning of the season.

Trichogramma minutum Riley

(Family Chalcididae)

This very common egg parasite, one of the smallest known insects, was figured and described by Riley in the "Third Report on Insects of Missouri." The material that he had emerged from the eggs of *Basilarchia archippus* Cram. that were collected in Missouri. Girault[7] says that the following are synonymic species: *pretiosum, minutissimum, intermedium* and *odontotae.* The types of the species in synonomy were lost or never deposited. *T. odontotae* Howard is a doubtful synonym of *T. minutum* in that this particular form has been reared from only the one host.

The species is recorded from both hemispheres. The following is a list from Girault.[7]

Western Hemisphere

North America: United States, Canada, and West Indies

Eastern Hemisphere

Europe: Germany, Austria
New Zealand: Waikumate and Wellington
Java
Hawaii

As the known distribution is so wide-spread, no doubt further collecting will show that this tiny insect is cosmopolitan in its range. Girault seems to think that "food is a factor of more than usual importance in limiting its range."

Host Records of *Trichogramma minutum* Riley

This egg parasite is known to parasitize well over one hundred and fifty hosts in seven orders; Lepidoptera, Coleoptera, Hymenoptera, Megaloptera, Neuroptera, Diptera, and Hemiptera (?).

Known records indicate that Lepidoptera are the favored hosts. In the partial list gathered from literature at hand these are forty-six species of Lepidoptera recorded as hosts out of the list of sixty-four species.

Girault states that the largest numbers of this parasite's hosts are lepidopterous and later points out that the coleopterous and hymenopterous hosts are closely related to moths and butterflies. In the same paper he makes a statement that all the hosts' larvae "feed upon foliage of various trees and plants—none are wood-boring, carnivorous, or predaceous in the larval stages." In the same paper he then lists *Chauliodes rastricornis* Rambur, a Megalopteran, whose larva *is* predaceous. The author is able to report another Megalopteran that serves as a host, *Sialis infumata* Newm. (Family Sialidae). So far as we are aware, no one has listed this genus as a host. In 1922 Smith[16] reported that it parasitized the eggs of Chrysopidae (Order Neuroptera).

Tabanidae (Order Diptera) were first reported as hosts by Cameron[3] in July, 1926. *Chrysops mitis* O. S., *Chrysops moerens* Walk., *Tabanus phaenops* O. S., *Tabanus punctifer* O. S., were recorded before; *Chrysops excitans* Walk., *Chrysops striatus* O. S., and *Tabanus lasiophthalmus* Macq.

A European writer, Kryger, has reported *Trichogramma evanescens* West. as a parasite on the eggs of *Sialis lutaria* L. (both European species). He also listed tabanid and stratiomyid eggs as serving as hosts for *T. evanescens* West.; so it is very probable that *T. minutum* Ril. will sometime be found parasitizing the eggs of Stratiomyidae in this country.

The Order Hemiptera is listed with a question mark as we have only the information from a correspondent that he has been working with *Trichogramma sp?* that were parasitic on lepidopterous and hemipterous eggs (Mr. C. O. Bare, Tampa, Fla.). Cameron says that Hemiptera eggs are parasitized but does not cite any species or references.

The following is a partial host list made from the literature listed in the bibliography* at the end of this paper.

Host List of **Trichogramma minutum** Riley

* This list is largely from Girault.

ORDER COLEOPTERA

Family Chrysomelidae

Odontota dorsalis Thunberg
Odontota suturalis Thunberg

ORDER LEPIDOPTERA

Family Papilionidae

Papilio glaucus Linn.
Papilio glaucus turnus Linn.

Family Nymphalidae

Polygonia interrogationis Fabr.
Vanessa atalanta Linn.
Agraulis vanillae Linn.
Aglais milberti Godart
Basilarchia archippus Cramer

Family Lymnadidae

Danaus plexippus Linn.

Family Tortricidae

Tortrix fumiferana Clemens
Tortrix citrana Fernald
Platynota rostrana Walk.
Polychrosis botrana Schiff.
Archips rosaceana Harris
Laspeyresia pomonella (Linn.)
Bactra lanceolana Hub.

Family Pyralidae

Phlyctaenia ferrugalis Hub.
Pyrausta nubialis Hub.

Family Pieridae

Eurymus eurytheme Boisd.
Pontia rapae Linn.

Family Agapetidae

Oeneis macounii Edwards

Family Hesperiidae

Calpodes ethlius Cramer
Thanaos lucilius Lintner
Goniurus proteus (L.)

Family Sphingidae

Smerinthus sp.
Phlegethontius sexta Johanssen
Ceratomia catalpae Bois

Family Notodontidae

Datana intergerrima G. & R.
Ianassa lignicolor Walk.

Family Liparidae

Euproctis chrysorrhoea Linn.

Family Noctuidae

Omiodes meyricki
Omiodes blackburnii
Omiodes accepta
Peridroma margaritosa caucia Hub.
Aletia argillacea Hub.
Autographa brassicae (Riley)
Heliothis obsoleta Fabr.
Laphygma frugiperda S. & A.
Mamestra picta Harris
Plathypena scabra Fabr.

Family Arctiidae

Hyphantria cunea Drury
Hyphantria textor Harris
Estigmene acraea Drury

Family Ceratocampidae

Anisota senatoria S. & A.

Family Crambidae

Diatrœa saccharalis Fab.
Diatrœa striatalis

ORDER HYMENOPTERA

Family Selandriidae

Eriocampoides limacina (Retzius)

Family Tenthredinidae

Caliroa obsoleta Norton
Caliroa aethiops Fabr.

Family Nematidae

? *Pachynematus palliventris* Cresson
Pteronus ribesii Scopoli

Family Cimbicidae

Cimbex americana Leach

ORDER MEGALOPTERA

Family Sialidae

Chauliodes rastricornis Rambur
Sialis infumata Newm.

ORDER NEUROPTERA

Family Chrysopidae

Chrysopa spp.

ORDER DIPTERA

Family Tabanidae

Chrysops mitis O. S.
Chrysops moerens Walk.
Chrysops striatus O. S.
Chrysops excitans Walker
Tabanus phaenops O. S.
Tabanus punctifer O. S.
Tabanus lasiophthalmus Macq.

Collecting and Cage Technique

Adults of the parasite were first obtained by placing the egg masses of *Sialis infumata* Newm. in four-ounce homeopathic vials. The mouth of the bottle was covered with a bit of cloth, held in place by a rubber band. Moist sand was kept in the first cages, but this was soon abandoned as fungous growths became quite heavy in some of the cages. The best results were obtained in cages that were dry, the moisture from the eggs and bits of plant stems seeming to be sufficient to keep the eggs in proper condition for the developing parasites and host embryos. Life history cages were also kept dry. Later in the season adults of the parasites were collected in the field while ovipositing in the egg masses of *Chrysops.*

The first emergence was that of a lone, winged female. This individual appeared on the twenty-sixth of June, dying two days later, imprisoned in some of the fungous growth that had started in the cage. No others emerged in this cage until seven days later. The first insects of the other cages were wingless males; an hour or so later winged females appeared. At a later date wingless females were found but no winged males were ever found. An examination of the wingless individuals showed that they possessed tiny, round scales attached to the points on the thorax where the wing bases are attached in winged specimens. These scales, or rudiments of wings, would float at right angles to the thorax when the insect was placed under water.

The males did not always emerge ahead of the females. At times the females were found in the cages an hour or two before the appearance of the males and were observed to oviposit many times before copulating with the late-appearing males. Authors say that the species is parthenogenetic.

Two winged females that have their antennae densely clothed with long hairs were taken from cages. One emerged from material that was collected early in the season and the other emerged from material that was collected late in the season. (See plate III, fig. 3.)

Cage Counts

Cage counts were made so as to determine the percentage of parasitism at different times of the season. While making these counts the number of winged and wingless individuals was kept. No attempt was made to determine the sex because of the large numbers present. In the thirty-six cages of *Sialis* field material there were six cages in which the number of wingless forms exceeded those of the winged. Of the series of eleven life history cages containing *Chrysops* egg masses, there was only one cage that had in it more wingless insects than winged ones. So while winged individuals are usually predominant in the broods, now and then broods appear where the wingless form is predominant. Most of the cages containing a predominance of wingless insects were cages of material collected in the fore part of the season. The average percentage of winged forms in the sixty-six cages was seventy-five per cent.

Habits

In the field and in the cages the parasites continually moved about nervously over the egg masses and up and down the plant stems, walking much and flying little. While on the egg mass the females were constantly searching over it with their antennae; the

Chart Showing the Percentage of Winged and Wingless Individuals

Data from Sialis Field Cages

Cage No.	Date of Emergence	No. of Winged	No. of Wingless	Per Cent Winged	Per Cent Wingless
1	7–2–26	110	68	61.8	38.2
2	6–29–26	32	69	31.7	68.3*
3	6–29–26	141	159	47.0	53.0*
4	7–2–26	14	28	33.4	66.6*
5	6–28–26	91	107	46.4	53.6*
6	6–29–26	210	151	58.1	41.9
7	7–1–26	92	34	72.2	27.8
8	7–4–26	30	5	94.2	5.8
9	6–28–26	307	165	65.0	35.0
10	6–29–26	100	35	74.0	26.0
11	7–1–26	55	60	47.9	52.1*
12	7–3–26	75	25	75.0	25.0
13	7–4–26	25	5	83.4	16.6
14	6–30–26	50	18	64.8	35.2
15	6–28–26	60	24	71.4	28.6
16	6–28–26	105	55	65.7	34.3
17	7–1–26	1320	1200	52.5	47.5
18	6–28–26	125	100	60.0	40.0
19	6–28–26	80	25	76.2	23.8
20	6–28–26	216	144	60.0	40.0
21	7–1–26	225	131	63.3	36.7
22	6–26–26	38	11	77.6	22.4
23	7–2–26	325	245	57.1	42.9
24	6–30–26	226	69	76.6	23.4
25	7–2–26	155	50	75.7	24.3
26	7–2–26	32	22	61.5	48.5
27	7–2–26	700	180	81.7	18.3
28	7–2–26	186	109	60.1	36.9
29	7–1–26	2352	1755	57.2	42.8
30	7–7–26	5	11	31.2	68.8*
31	7–2–26	1417	669	67.5	32.5
32	7–8–26	1595	1092	59.3	40.7
33	7–1–26	20	5	80.0	20.0
34	7–1–26	352	117	75.3	24.7
35	7–2–26	16350	2070	88.8	11.2

The average number of winged specimens in the cages of *Sialis* field material was 75 per cent, of wingless 25 per cent.

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* Marks cages where the number of winged is less than the number of wingless.

Data from Sialis Life History Cages

Cage No.	Date of Emergence	No. of Winged	No. of Wingless	Per Cent Winged	Per Cent Wingless
2–4	7–16–26	121	25	82.9	17.1
2–5	7–14–26	62	76	44.5	55.5*
2–6	7–14–26	153	53	74.3	25.7
2–7	7–14–26	169	21	88.9	11.1
2–9	7–14–26	139	35	79.9	20.1
2–10	7–14–26	116	26	81.7	18.3
2–11	7–14–26	153	50	76.2	23.8
2–12	7–14–26	516	220	70.2	29.8
13–1	7–15–26	233	96	70.9	29.1
27–4	7–15–26	239	55	80.6	19.4

Data from Chrysops Life History Cages

Cage No.	Date of Emergence	No. of Winged	No. of Wingless	Per Cent Winged	Per Cent Wingless
2–4–a	7–28–26	22	18	55.0	45.0
2–6–a	7–27–26	28	28	50.0	50.0
2–7–a	7–27–26	14	16	46.6	53.4*
2–11–a	7–27–26	16	8	75.0	25.0
2–12–a	7–27–26	48	35	57.9	42.1
2–12–b	7–29–26	27	7	79.5	20.5

Data from Chrysops Field Cages

68	7–21–26	314	130	70.8	29.2
69	7–21–26	370	126	74.6	25.4
70	7–21–26	176	45	79.7	20.3
71	7–21–26	83	32	72.3	27.7
72	7–21–26	201	60	77.4	22.6
73	7–21–26	200	62	76.4	23.6
74	7–25–26	75	28	72.9	27.1
75	7–25–26	35	7	83.4	16.6
76	7–25–26	175	31	85.0	15.0
77	7–26–26	30	8	79.0	21.0
83	7–23–26	331	86	79.9	20.1

Total number of winged specimens	31,357
Total number of wingless specimens	10,407
Grand total	41,764
Per cent of winged specimens	76
Per cent of wingless specimens	24

* Marks cages where the number of winged is less than the number of wingless.

males behaved in the same manner. Often the females were observed to stop to clean their wings, stroking them with the hind pair of legs as they pulled them down alongside the abdomen.

Copulation

Most of the copulation took place on the egg mass where the males were always roaming and where the females returned from other parts of the cage. Suddenly a male would dash to a passing female, grasp her wing tips with his front pair of legs, hook his head over the tips, swing up and hold to the wings with the other legs. Thus hanging in an underslung position he would copulate with her, the act lasting usually from four to ten seconds. Then he dropped off and would perhaps go immediately to some other passing female. One male was observed to copulate with three females in rapid succession, going immediately from one to the next. Some females kept moving about while copulation was carried on, as though attempting to shake the male off; others stood quietly. (See plate I, fig. 8.)

Oviposition

The parasite could oviposit in *Sialis* eggs that were in the center of the mass, only around the base of the micropyle. Any spot on the eggs in the outside rows seemed favorable, as was also true with *Chrysops* and *Tabanus* eggs. As Cameron[3] observes, the egg to be oviposited in was apparently picked at random. When a *Sialis* egg was selected, the female walked over it until a position for oviposition was reached. Then the wings were raised and the abdomen lowered between the micropyles until the ovipositor could be inserted in the chorion. With many females there was at first a slight back and forth movement as the ovipositor sawed through the chorion. The female was then quiet until oviposition was complete.

The deposition of an egg inside the host egg seemed to stop all development of the host egg, unless the host embryo had already used much of the yolk. It is not known just how old the host larva must be before it is able to tolerate the parasite and continue to develop. The parasites seemingly do not pay any attention to the age of the host egg. Both in the field and in the laboratory they were observed to oviposit in eggs that were almost ready to hatch.

Inside the laboratory the females oviposited any time of the day but when taken into bright sunlight they refused. All that were found ovipositing in the field were observed always after four o'clock in the afternoon. It is hoped that it will be possible to gather more data next summer on light as a factor in the oviposition behavior of this parasite.

Holloway[11] reports that he was able to induce a female *Trichogramma* to oviposit in the juice globules of okra plants. This fact might lead one to believe that a female will oviposit in any egg but it has been found that there are eggs in which they refuse to oviposit or to which they are not attracted. The writer was unable to get them to oviposit in *Donacia* or gyrinid eggs, possibly because of the nature of the chorion, though Gatenby maintains in his embryological paper on *Trichogramma evanescens* Westw. that they will oviposit in *Donacia* eggs. However, we believe that Mr. Gatenby is in error as to the identity of his eggs. (See plate III, figs. 5, 6 and 7.)

What Gatenby more than likely had were the eggs of *Sialis lutaria* Linn., the most common *Sialis* of Europe. This insect is reported by several European writers as being one of the hosts of *T. evanescens.* His figure 2 (Plate I, fig. 5) is a very excellent outline of a *Sialis* egg that has lost its micropylar projection. All the *Donacia* eggs with which we are familiar, either in nature or in literature, are not set up on end as his fig. 3A (Plate I, fig. 7) shows but are usually glued to the surface on the side. In one species they are laid one against the other at oblique angles. The mass is not symmetrical as shown in Gatenby's figure 8 (Plate I, fig. 6).

In his text Gatenby describes his eggs as being of various shades of brown, depending on the stage of development of the embryo within. Then it is stated that "the egg groups do not adhere very closely to the surface of the reed and they are easily removed by bending the surface on which they are laid," descriptions that fit *Sialis* eggs very nicely. All the *Donacia* eggs with which the writer is acquainted, or can find described, are not of a brownish color but are of an opaque white color. *Sialis* eggs are always of a brownish color. Even when the eggs are freshly laid they are of some shade of brown. *Donacia* eggs are glued firmly to their support and do not come off as easily as *Sialis* eggs do.

Harland[8] found that *T. minutum* refused to oviposit in the eggs of the Cotton Stainer (*Dysdercus delauneyi*) and also that no attention was paid to various spider eggs.

Duration of Oviposition

The following records were made at different times of the day on the duration of oviposition. The last two counts were taken on females that were fairly well spent.

Female No.		Female No.	
1	15 seconds	7	21 seconds
2	20 seconds	8	22 seconds
3	20 seconds	9	25 seconds
4	20 seconds	10	30 seconds
5	20 seconds	11	60 seconds
6	20 seconds	12	60 seconds

Number of Progeny of Each Female

In the life history cages counts were made of the number of females put in and later progeny counts were taken so that in this way it was possible to find the average number of progeny per female.

Average Number of Progeny per Female

Cage No.	Number Females	Number Progeny	Average No. of Progeny
1	4	15	3
2	4	14	3
3	15	138	9
4	15	203	13
5	10	142	14
6	15	250	16
7	16	329	20
8	12	206	17
9	8	174	21
10	8	190	23
11	16	736	46
12	16	736	46
13	6	294	49
14	4	350	87(?)

Dissections of several females were made and the following ova counts obtained:

Female No.		Female No.	
1	30	5	47
2	30	6	48
3	40	7	50
4	47	8	52

Bodkin,[2] in working with a very closely related parasite in British Guiana, gives an idea of the maximum number of progeny that a single female will produce. He had one female make one hundred ovipositions from which eighty adults developed. Our cages at Douglas Lake were probably not observed over as long a period as his. Possibly the average number of progeny of the insects worked with at Douglas Lake was larger than the data given here would indicate. The average number of ova dissected from each female was forty-one, the maximum number fifty-two. The dissections were made in the afternoon on females that had emerged in the morning on the same day. Cage number fourteen, where there was an average of eighty-seven progeny, is to be questioned until further checks can be made. No explanation is offered for the two exceedingly low cages unless these females had already spent themselves before they were put in the life history cage. Possibly some unknown factors entered, such as humidity and toughness of chorion.

Life History Studies

As soon as the parasites began to emerge studies of the egg, larval and pupal stages were begun. Considerable difficulty was encountered in obtaining parasite-free eggs at the times when they were needed. At first attempts to secure them were made by confining a number of *Sialis* adults in cages but few would ever lay while in captivity. At times a sufficient number of eggs were collected by going to the *Scirpus* patches about two o'clock in the afternoon and hunting females that were ready to or just beginning to oviposit. The stem on which the female rested was plucked and either held in the hand or put in a live jar while search was continued for others. On several days a large number of masses was collected in this way. *Chrysops* eggs were collected in the same manner. However the *Chrysops* female was much more wary than the *Sialis* female and would often fly, leaving the mass only partially laid. When kept in a live jar they usually flew off the stem upon which they were ovipositing and would finish on the sides of the jar.

In the laboratory a number of female parasites were released in the cages with the fresh eggs collected. The method of transferring was simple. The mouth of the cage containing the eggs to be parasitized was turned upside down over the mouth of the cage confining the parasite. The females flew up, one and two at a time; others crawled up the sides of the cages. It was not necessary to turn the cages toward the light, as these insects are negatively geotaxic.

The different stages of the parasite were searched for by dissection of the host egg. This was an unsatisfactory method, as the first stages are so nearly the color of the contents of the host egg that it was with considerable difficulty that the parasite could be found. Often a whole morning would be spent without finding any of the early stages. When one was found, the dissected egg was kept on a slide in a moist chamber. The egg of the parasite was always lost when the slide was examined again. Possibly the dissection of the host egg caused it to collapse. Sometimes it was possible to hold a mature larva or pupa a short time, but it was never possible to carry them through to emergence. Enough data were gathered in this way to determine something as to the length of the stages and other facts concerning the biology.

Attempts were made to keep some of the dissected material in a medium consisting of the yolk of hen's egg and also a medium of crushed eggs of the host but they failed rather miserably. To add to the troubles, fungous growths started very easily in spite of attempts to provide clean cultures.

Attempts were also made to watch the parasite through the chorion. This was impractical with *Sialis* eggs, as they are so dark that it is almost impossible to get light through them. With *Chrysops* eggs it was possible to get light through the chorion, but here the same difficulties arose as with dissection. How could one differentiate the parasite egg or larva from the yolk contents of the host egg?

From the results obtained with preserved material it is believed that nearly the whole cycle can be followed by killing the eggs in hot alcohol and later dissecting. In this way the contents of the egg are coagulated and it is quite easy to find the parasite. Some host eggs coagulated more easily than others.

The Egg

The eggs found in the host eggs were almost colorless. In general the shape is elongate-ovoid, being broad at one end and tapering to a point that is about half the width of the widest part. The shape varied for individual eggs. The following measurements were made of ova dissected from the ovaries of female parasites. The measurements were made at the longest and widest part of the ova.

Eggs of this insect found in the host egg measured from .108 mm. to .120 mm. in length and from .032 mm. to .038 mm. in width.

Length of Incubation

The exact length of the time of incubation is not known. From dissections made of preserved material it is known quite definitely that the period is twenty-four hours or less in length.

MEASUREMENTS OF THE OVA OF *Trichogramma minutum* RILEY
(Dissected from ovaries)

Length	Width	Length	Width
.089 mm.	.003 mm.	.112 mm.	.036 mm.
.089	.026	.112	.036
.100	.039	.112	.039
.100	.039	.115	.039
.100	.036	.115	.049
.102	.036	.118	.037
.105	.033	.118	.046
.105	.036	.125	.039
.108	.027	.132	.056
.108	.032	.138	.062
.108	.039	.138	.062
.109	.032	.140	.064
.112	.033	.148	.056

The Larva

The skin of the larva is of a transparent white color, while the contents of the body are usually of a dirty yellowish-white, the same color as the contents of the host egg. The only appendages that the larva possesses are two flattened, cone-shaped, straw-yellow oral hooks. In a larva two days old they are .026 mm. in length and .006 mm. in width near the base. Authors seem to think that the function of the oral hooks is to "shovel" food into the mouth opening which lies just above their bases. The writer has slide mounts showing the mouth pressed tightly against the material of the host egg and with the oral hooks on the outside of the material. The oral hooks have never been observed to move in live material but there is no doubt but that their function is to help in getting food into the mouth.

There is no metameric segmentation of the body, though in some specimens several creases and ridges appear, marking the cephalic end of the larva from the rest of the body. The whole organism is sac-like in shape, conforming to the cavity in which it rests. Where it is found at the end of the host egg, the larva is often pressed so tightly between the material of the host egg and the chorion that a finger-like prolongation is found filling the space between the chorion and the rounding of the host egg contents. Gatenby[5] tells us that in *Trichogramma evanescens* the tracheae, ordinary mouth parts, heart, and oesophageal valve are wanting. The same is true for *T. minutum*.

Food Habits and Growth

The larva rapidly swallows the contents of the host egg until all have been crammed into the sac-like body (in the case of *Sialis* and *Chrysops* eggs). The body wall of the larva grows thinner and thinner as more material is taken in, until the parasite fills the *Sialis* egg, and about two-thirds fills the *Chrysops* egg. Apparently not much digestion takes place until all the yolk has been swallowed, so there is no waste material to be defecated in the earlier development. Whether it defecates later is not known for sure, but more than likely it does not.

Gatenby[5] asks how the larva of *Trichogramma evanescens* gets the yolk disclets from the caudal end of its body to the cephalic? From our observations of *Trichogramma minutum* we would say that the material never lies at the caudal end of the body but that the larva keeps pressed against the chorion of the host egg so that as it grows in size it keeps the yolk disclets continually pressed forward. When the last disclets are to be swallowed they are at the cephalic end ready to be swallowed, rather than at the caudal end of the larva.

A larva that is between a day and a half and two days old is .120 mm. in length while the prepupal stage, which is two or three days later, is .130 mm. in length. Thus it is apparent that most of the growth comes about during the first two days of the larval life. The larval and egg stage cover a period from six to seven days. A prepupal stage follows the larval stage but nothing is known as to the length of it.

Number of Larvae in an Egg

In *Sialis* and *Chrysops* eggs it would be a physical impossibility for more than one larva to reach maturity. In all dissections made only one larva was ever found in one of these eggs. Whether the females are instinctively aware of this fact is not known. Gatenby[5] states that he rarely found two eggs or two larvae in the sections of his supposed *Donacia* eggs. *Tabanus* and other large eggs are able to support more than one larva and generally several are found in the larger eggs. In such eggs the parasite lays its eggs in such close proximity that it is a common occurrence to find two larvae lying together in close contact, especially those at the poles of the egg. It is very doubtful if these larvae could injure one another except by causing starvation and this is not likely to happen in a *Tabanus* egg. As many as five larvae have been dissected from a *Tabanus* egg. Usually there are two at each pole and one in the center of the egg. Howard and Fiske[12] report that the largest number of parasites developing from one egg to be 10. These were obtained from one Browntail Moth egg. Kryger obtained 13 adult parasites of *Trichogramma evanescens* from lepidopterous eggs.

The Pupa

The newly formed pupa is of a yellowish-white color. As it grows older it gradually turns darker until two or three days before emergence it is of the same black color as the adult. The measurements for the pupa are almost the same as for the adult. The total length averages .39 mm., the width of the abdomen, .30 mm., and the length of the wing pads .039 mm. When the life history runs fourteen days this stage is seven or eight days long. As is characteristic of this family, no cocoon is spun, the chorion of the host egg being sufficient protection. Sometimes the pupa is found lying upside down in the host egg.

Appearance of the Parasitized Host Egg

As many authors mention, the host egg turns darker after it has been parasitized a few days. When the parasite has pupated, the egg turns black, possessing a peculiar sheen that marks it from non-parasitized eggs of the mass.

Emergence of the Adult

Hungerford[13] has published the following notes on the emergence of this parasite from the eggs of the European Rose Slug, *Caliroa aethiops* Fabr. "From one egg, from one to three wasps issued. . . . From one egg three came forth, one following the other in quick succession. The tiny wasp cuts its way from the egg shell with its mandibles. The time required for the process in one case was thirty-five minutes from the first puncture of the egg, until the wasp emerged. Where there are more than one wasp in the egg the second wasp sometimes enlarges the exit hole of the first before attempting to pass. As soon as the wasp comes forth and while the wings are still pads it can jump an inch with alacrity. They fill out in about four minutes."

Emergence Response to Light

Wolcott[17] in working with this parasite found that they show an emergence response to light. He had trouble with this being strongly positively phototropic, so placed his cages in the dark. When the cages were removed from the dark he found the greater number contained no adults but that in the next hour of exposure to light a large emergence took place. He came to the conclusions that " . . . the normal time of emergence is approximately two hours after sunrise" and that in his cages " . . . six times (6.19) as many adults of *T. minutum* emerged in the first hour after being exposed to daylight, as emerged in the dark per hour of previous daylight in the same day."

Length of Emergence

On a check of some field material it was found that emergence in the same brood continues one and even two days after the first day of emergence. No accurate check was made of other cages, as was done with the above mentioned but it was noticed that in other cages the numbers were sometimes quite noticeably greater on the second and third days. In the same cages checks were also made on the length of the life of the adult in the cage. In all four cages they lived for a period of four days without food.

Length of Life History

The complete life history ran from fourteen to sixteen days in the *Sialis* cycle which occurred during the fore part of the season. The greatest number of parasites emerged on the fourteenth day. The average temperature for this generation was 66.8° F. During the *Chrysops* cycle the period ran from thirteen to sixteen days, as in *Sialis* eggs. The temperature average reached its peak during this generation at 75.4° F. The sixteen day cycle occurred in two cages, a *Sialis* cage and a *Chrysops* cage, that contained host eggs that were laid before the maximum average temperature had been reached. Taking all the cages collectively, the average length of the time in the host egg was fourteen days. After the *Chrysops* cycle, the *Tabanus* cycle began, and probably other hosts also began to lay eggs at this time. At this period the average temperature was beginning to fall. No data were obtained from *Tabanus* eggs in the field because of lack of time and material. Howard and Fiske[12] record as short a period as nine days and as long a period as three weeks in the fall for the length of the life cycle in the host egg. Their work was done with the Browntail Moth in Massachusetts.

Incubation Period of Host Development of the Parasite

The parasite's life history cycle ran side by side with the incubation period of the host during the first part of the season. As the season grew warmer the incubation period of the host shortened while the cycle of the parasite remained at about the same place. Later in the season instead of finding the parasite emerging on the same day that the host larvae were hatching, it was emerging as long as twelve days after the hatching of the unparasitized host eggs.

The following chart gives comparative data.

LENGTH OF SIALIS INCUBATION COMPARED WITH PARASITE EMERGENCE

From Field Material (Emergence from 6/26 to 7/8/1926.)

No. of days by which parasite incubation exceeded host incubation	0	1	2	3	4	5	6	7	8	9	10	11	12
No. Cages	7	7	4	7	3	1	1	0	0	0	0	0	0
From Life History Material. (7/14 to 7/16/1926.)													
No. Cages	0	0	0	0	0	4	1	5	2	1	0	0	0

LENGTH OF CHRYSOPS INCUBATION COMPARED WITH PARASITE EMERGENCE

From Field Material. (7/17 to 7/29/1926.)

No. of days by which parasite incubation exceeded host incubabation	0	1	2	3	4	5	6	7	8	9	10	11	12
No. Cages	0	0	0	0	0	0	0	0	0	0	0	8	2
From Life History Material. (7/20 to 7/25/1926.)													
No. Cages	0	0	0	0	0	7	1	2	0	1	0	0	0

Number of Generations

During the two months spent working with these parasites there were four successive generations upon which notes were taken. At least five other generations, not successive but overlapping each other and the successive four, appeared. A sheet made up of emergence dates of field material, life history cages, and field notes, show that there was an almost daily emergence of the parasite throughout the season. No distinct generations appeared.

How the Parasite Overwinters

No one knows definitely just how the parasite does overwinter. Howard and Fiske[12] have published some temperature results that give a hint as to how this insect spends the winter. They say that "if the temperature falls below certain limits, the young parasites will hibernate or attempt to hibernate and thereafter their development may be delayed for several weeks, even months, even though they are exposed to continuous high temperature during this period." More than likely the winter is passed in some lepidopterous egg.

Percentage of Parasitism

In studying the charts of percentages of parasitism over the span of the season that the data were gathered, it can be inferred that in this particular season, and it would probably be true for other seasons, the numbers of the parasite that successfully pass the winter were few. The first host eggs found were those of *Sialis infumata* Riley. These eggs were, with the exception of one cage, parasitized very lightly. *Sialis* eggs are laid in a single decked mass so that it is very easy for the parasite to reach all the eggs in the mass. The average per cent of parasitism for the thirty-six cages of field material that were parasitized about the middle of June was .019 per cent counting approximately 2,045,075 eggs.

The next host that followed was *Chrysops*. In making counts of these eggs two numbers had to be taken into consideration—the number of eggs actually exposed to parasitism and the number of eggs in the whole mass. *Tabanid* eggs are usually laid in heaped masses, so that many of the eggs in the mass cannot be reached by the parasite. In the field cages that contained material parasitized during the last part of June and the first of July, there was a parasitism of 11 per cent for 22,468 eggs, the total number of eggs in the masses. When only the eggs exposed to the parasite were considered, the average was, of course, higher, being 17 per cent for 15,258 eggs.

The life history cages of the two hosts may be used as checks for the field material, for here all factors were practically the same for both hosts, which was not true in the field. Parasitism of the two hosts in the life history cages ran about parallel. The average for *Sialis* eggs was 16 per cent; for *Chrysops* eggs exposed to the parasite, 20.8 per cent, and for the actual number of eggs in the masses, 11.5 per cent. The average for these two percentages was 16 per cent. This would indicate that under the same conditions the *Sialis* eggs would be parasitized as heavily as the *Chrysops* eggs, which was not true in the field. One cage of *Sialis* eggs had a 40 per cent parasitism which indicates further that the parasite will parasitize *Sialis* eggs more heavily than the data obtained would indicate.

On August 8, 1926, six masses of *Chrysops* eggs were picked at random in the field and later counts made by counting the number of parasite emergence holes. The emergence hole of the parasite is very distinctive and can be recognized quite easily. It is a round, more or less jagged-edged hole, while the host larva emerges through a slit at the cephalic end of the egg. As the parasites emerged from these on the 10th of August, it was evident that they were parasitized some time during the last part of July. The per cent of parasitism of these masses was cut down because one mass was not parasitized, an unusual find in the field at this time of the season. The highest parasitism was 98 per cent and excluding the mass not parasitized, the lowest was 90 per cent. The average per cent for the eggs exposed to parasitism was 86.7 per cent and for the number of eggs in the masses 59.8 per cent; these two figures average 73 per cent.

Thus as the season advanced, the larger the numbers of the parasite grew, but yet they lagged so that the host was allowed to establish a good-sized brood before the parasite numbers were large enough to make any inroads on the numbers of the host. So the host is not threatened with extermination but rather parasitism acts as a factor in helping to maintain the balance of nature. This is done by the reduction of what might be called the surplus numbers of the host. This reduction lessens the danger of the species becoming exterminated by its own numbers. Furthermore, the reduction of these numbers prevents no more than a normal disturbance of some other species that might serve as host.

About the same situation exists with the European Corn Borer.[1, 14] It has been published that "this parasite is of little value in control of the European Corn Borer, except in subnormal seasons because its highest parasitism comes too late in the season to give the best results."

Now when the time of the season has come that the parasite has increased its numbers so greatly and the egg laying season of the old host is past, it must find another host or hosts to support the large numbers that are now in the field. Unfortunately the Biological Station closed at this time so we are only able to offer suggestions as to what host that parasite now goes. We collected two large masses of *Tabanus* eggs and parasitized them in the laboratory and then killed the eggs in hot alcohol. Later the eggs were dissected.

It was found that there were usually three parasites in a single *Tabanus* egg. Often as many as five were found, as has been mentioned before. The number of eggs in a single mass was also greater than in a *Chrysops* mass, so that if the *Tabanus* masses became as numerous as the *Chrysops* masses were, they could support the larger numbers of parasites as easily as the *Chrysops* had supported the smaller numbers in the earlier part of the season. As the parasite has a large host list it is probable that other hosts absorb the increase.

While Girault[7] seems to think that the abundance of food is the only factor of importance that acts as a check on this parasite, there are other factors that might be pointed out that probably play an important part in keeping the numbers of the parasite reduced. Howard and Fiske have said that the toughness of the chorion of the host egg was effective in the reduction of the parasitism by this insect in the case of the browntail moth. Harland[8] reports that the oviposition of the parasite is not effective at times with the Corn Worm (*Laphygma frugiperda* S. & A.) because the felty covering of the egg varied in thickness so that with some eggs it was thick enough to keep the parasite out. Harland also thinks that they refused to oviposit in the eggs of the Bean Leaf Roller (*Eudamus proteus* L.) because of a thin layer of some viscous substance on the chorion that had a repellent effect on the parasite.

The willingness to oviposit is a factor in keeping the numbers reduced. The female will oviposit in an egg with an embryo almost matured as readily as she will in a fresh egg. Because of this trait many eggs are laid that perish very soon. This was observed both in the field and in the laboratory. Howard and Fiske mention in their report that this insect will oviposit in eggs containing embryos. Their observations were limited to the laboratory.

Winter is probably a very important factor in the reduction of the season's numbers. From the data collected it is evident that only a small number ever pass through the winter successfully.

Conclusion

This parasite is a very successful organism. One of the reasons for its success is because it has such a large number of hosts. From the present studies and from the literature it can be pointed out that the parasite numbers rarely become so large as to effectually reduce the numbers of the host to any appreciable extent. The parasite plays its part in the reduction of the numbers of the host only at the end of the laying season when a "pruning" is of more value than harm to the host. Another reason for its success is that its numbers are reduced at the end of each season by winter.

CHART OF SIALIS EGG PARASITISM

From Field Material

Material Collected from 6/22/26 to 7/1/26

Cage No.	No. of Sialis Eggs	No. of Parasites	Percentage of Parasitism
1	5,075	178	.033
2	16,850	101	.006
3	150,000	300	.002
4	13,750	42	.003
5	30,875	198	.006
6	53,000	361	.006
7	12,870	126	.006
8	28,920	35	.001
9	61,000	472	.007
10	30,000	135	.0045
11	48,000	115	.002
12	50,000	100	.001
13	20,000	30	.002
14	25,000	68	.002
15	34,000	84	.002
16	70,000	160	.028
17	86,000	2,520	.003
18	57,600	225	.004
19	26,200	105	.008
20	47,705	360	.007
21	30,600	356	.012
22	48,300	49	.001
23	8,500	570	.065
24	85,600	295	.003
25	28,800	205	.007
26	16,000	52	.003
27	22,200	980	.044
28	85,600	295	.034
29	34,750	4,107	.118
30	46,000	16	.0003
31	26,400	2,086	.079
32	10,500	2,687	.255
33	19,200	25	.001
34	15,300	469	.030
35	8,000	3,200	.400
36	570,000	18,420	.320

39,457 parasites emerged from approximately 2,045,075 *Sialis* eggs, giving an average parasitism of .019 per cent.

Chart of Chrysops Egg Parasitism

From Field Material

Cages 68–77 Collected on 7/8/26, Cage 83 on 7/14/26

Cage No.	No. of Parasites	No. Exposed to Parasite	Per Cent Parasitism	No. in Mass	Per Cent of Parasitism
68	444	800	.555	1,582	.281
69	496	2,175	.228	2,950	.168
70	221	1,508	.140	2,316	.095
71	115	1,090	.105	1,365	.084
72	261	2,000	.130	2,900	.090
73	262	2,146	.179	6,197	.132
74	103	810	.127	1,300	.079
75	42	1,235	.037	2,000	.021
76	206	1,010	.203	1,630	.126
77	38	1,195	.039	1,730	.021
83	427	1,965	.217	2,720	.157

Two thousand six hundred and fifteen parasites emerged from egg masses that contained approximately 22,468 eggs for an average parasitism of 11.6 per cent. The number of eggs actually exposed to parasitism was 15,258 eggs for an average of 17.1 per cent.

On August 8, 1926, a number of *Chrysops* masses were collected that had been heavily parasitized. The following counts were obtained by counting the emergence holes. The parasites had been allowed to emerge in a large cage in the laboratory.

Cage No.	No. Eggs Exposed to Parasite	No. Eggs With Emergence Holes	Per Cent Para.	Eggs in Mass	Per Cent Para.
M–1	100	0	.000	170	.000
M–2	90	88	.967	160	.544
M–3	125	115	.928	175	.677
M–4	110	106	.964	160	.662
M–5	500	490	.980	650	.753
M–6	100	90	.900	170	.529

Eight hundred and eighty-nine parasites emerged from egg masses that contained 1,485 eggs for an average percentage of .598. The number of eggs actually exposed to parasitism was 1,025 for an average parasitism of .867.

Summary

1. *Trichogramma minutum* Riley is found in both hemispheres.

2. It has a host list that numbers well over one hundred and fifty species in seven orders.

3. The author reports *Sialis infumata* Newn., *Chrysops striatus* O. S., *Chrysops excitans* Walker, and *Tabanus lasiophthalmus* Macq. as new hosts.

4. The numbers of the winged females usually exceed those of the wingless males and females.

5. This parasite reproduces parthenogenetically.

6. The author reports an aberrant form that has the antennae clothed with long hairs.

7. It is believed that strong light has a negative effect upon the oviposition of this parasite.

8. While this insect has been known to oviposit in the juice globules of okra plants, yet it refuses to oviposit in the eggs of *Donacia,* Gyrinidae, the Cotton Stainer (*Dysdercus delauneyi*) and also no attention was paid to spider eggs.

9. Gatenby's sections were made from *Sialis* eggs and not *Donacia* eggs.

10. The average number of ova dissected from females was forty-one. The average number of progeny was twenty-three. The ova measured .089 mm. to 148 mm. in length.

11. The larva is a sac-like creature with no metameric segmentation of the body and the only appendages possessed are a pair of oral hooks. Tracheae are not present.

12. The larva rapidly swallows the contents of the host egg, no digestion taking place until the larva has distended itself to full size.

13. Only one larva is able to develop to maturity in the eggs of *Sialis* and *Chrysops. Tabanus* eggs usually support three. The maximum number of *T. minutum* R. reported emerging from one egg is ten.

14. There is a prepupal stage. Its length is not known.

15. The larval and egg stages last from six to seven days in a fourteen day cycle. The length of the pupal stage is from seven to eight days.

16. Wolcott proved that there is an emergence response to light.

17. The average life cycle ran fourteen days. The incubation period of the parasite ran from none to twelve days longer than the incubation period of the host.

18. In the same brood emergence continues for a day or two.

19. There were no clean cut generations. An almost daily emergence occurred.

20. The parasite probably overwinters in the egg, larval or pupal stage in some lepidopterous egg.

21. Only a small number of parasites survive the winter.

22. Checks show that *Sialis* eggs are parasitized as heavily as *Chrysops* eggs when subjected to the same conditions. In the field *Sialis* eggs were parasitized very lightly.

23. In normal seasons the parasite numbers lag behind the numbers of the host eggs in the field until the peak of the host egg-laying season is reached.

24. The toughness of the chorion, the thickness of the chorion of the host egg, the viscosity of the substance on the chorion, the willingness to oviposit in eggs of any age, and winter, act as checks on the numbers of this parasite.

25. This parasite is very successful, for it has a very large host list. It does not threaten to reduce its host's numbers materially, except in abnormal seasons. At the end of the season its large numbers are reduced very materially by the rigors of winter.

Tiphodytes gerriphagus (Marchal)
(Family Proctotrypidae)

European Literature

This very interesting parasite was first described by Marchal in 1900 in the Annales de la Société Entomologique de France, under the generic name *Limnodytes.* In 1902, Bradley, in the Canadian Entomologist, Vol. 34, p. 179, proposed the new name *Tiphodytes* for *Limnodytes,* which was preoccupied. Marchal found the insect through his embryological studies of Gerridae. He was aware of the parasite's presence by the undulating movements of larvae which he could see through the chorion of the gerrid egg. He first found a larva that the third form of the parasitic larva of *Platygaster,* described by Ganin, resembles. Later he found what he called the first form of the larva, which he thought differed from *Platygaster's* first form by the arrangement of the bristles and by the caudal hook, which he thought was without a spine.

He imprisoned the adults in a glass tumbler and observed that they used their wings equally well in flying or in swimming through the water. His plates show that the males possess moniliform antennae while the females have clavate antennae. He gave no definite data on the life history. He mentions that he collected the gerrid eggs on the 14th of May and that the adults of the parasite emerged in June.

In 1918, Henriksen published under the old generic name, *Limnodytes*, about the same information concerning the larvae as Marchal published, going more into detail in the description of the larvae. He published with his paper a plate showing the egg and three larval stages which he labels as *Limnodytes sp.* and marks "copied after Ganin." Evidently his plates were not made from material at hand.

American Literature

The only literature from America concerning this insect is the paper published in 1912 by Matheson and Crosby in the Annals of the Entomogolical Society of America, Vol. V, page 67, March, 1912. They describe the swimming of the species and the laying of eggs in the *Gerris* eggs while under water. They mention that their determination was verified by Marchal. The specimens that the author possesses were identified through the kindness of Dr. S. A. Rohwer of the National Museum.

Field Notes Taken at Douglas Lake

The adults were very numerous at the north-western end of the lake at Marl Bay and in Bessey Creek which emptied into the lake near the bay. They were found flying about the lily pads or walking over them. Sometimes only one female was on a pad and then again several were on the same pad. After the female landed on a leaf she usually walked straight to the edge of it. When a suitable place was found, she first dipped her head under the surface film of the water and after a few struggles with it, succeeded in pulling herself entirely under water. Clinging to the underside of the pad, she walked about searching for gerrid eggs. Usually she did not have to search long as the gerrid eggs are laid along the under edge of the pad.

Oviposition was begun as soon as the eggs were found. Several times the leaves were turned over under the water so that the female could be observed. After ovipositing in two or three eggs she would let go of the surface of the pad and come quickly to the top and fly away from the surface of the water. The passage through the water from the leaf to the water's surface was so rapid that it was never determined if the wings were used or if the buoyancy of the insect's body brought it to the surface. More than likely she used her wings.

In the laboratory it was possible to watch oviposition much more closely than in the field. As soon as the female entered the water she wrapped her wings tightly about her abdomen, making it appear much longer than normal. The antennae were held back over the head tightly against the dorsal side of the body with the clubs close together. The insect leaned forward while ovipositing. This position made her appear as though she were almost overbalancing herself by the strenuous effort she was exerting in making the oviposition. The ovipositor was driven into the chorion of the host egg at an angle of 90 degrees. Usually no motion was noticed as the ovipositor was being thrust through, though sometimes a rocking motion was evident before the ovipositor had been thrust all the way in. Throughout the operation the tip of the abdomen was held close to the chorion of the host egg.

In the field the writer observed a second manner of oviposition that neither Mathewson and Crosby nor others have observed. As usual the female alighted on the pad and walked to the edge but she did not go under the water. Instead she turned around and backed into the water and clung anchored to the lily pad with the front pair of legs, while the middle pair hung in the water, and the hind legs floated on the surface film of the water, as did the wings also. In this position the female was able to reach the gerrid eggs with her ovipositor and oviposit in them. After ovipositing about twenty seconds the insect crawled back to the surface of the pad, wiped the abdomen off with the hind pair of legs, and flew away to another pad.

In the laboratory the females were observed to try to oviposit in the gelatin that covered *Trepobates* eggs. Sometimes they attempted to oviposit in the gelatine as many as five or six times before finally striking an embedded egg. We were never able to find out if an egg was actually deposited. The female assumed the same position as when laying in a gerrid egg and sometimes the rocking motion was noticed. No discrimination was made as to the age of the egg. Eggs containing gerrid embryos almost ready to hatch were oviposited in as readily as eggs that were much fresher.

Technique in the Laboratory

To carry on studies on individual eggs, slides were covered with paraffine and holes made in the wax to contain the egg. Each egg's number was scratched in the wax beside it. The slide was kept in a finger bowl in enough water to almost submerge it. This way the eggs were kept from drying and yet data could be kept on individual eggs. Paraffine wax did not prove very satisfactory as it broke loose from the slide after being in the water for a time and had to be watched very carefully to prevent the eggs from becoming mixed. When further studies are made the slide will be covered with sealing wax.

Other laboratory studies were made with preserved material. This material was killed in boiling 70% alcohol and kept in 70% alcohol. Gerrid eggs did not seem to coagulate and become as dense and tough as *Trepobates* eggs.

In the laboratory the larvae or pupae could be easily seen under the binocular. Keeping the eggs under water, the chorion of the host egg was carefully cut and picked with a small curved and a flat knife-like dissecting needle, fashioned from steel insect pins and sharpened on an oil stone. After the chorion was removed the tough, rubber-like egg contents had to be cut open. A cross cut was usually made near the parasite which is found lying in a cavity from which it can be picked. Considerable care must be used in removing the larva or the skin will be broken and the specimen ruined. The larva should not be allowed to become dry but should be put on a slide immediately. If allowed to dry the shin shrinks and sloughs off, leaving only the solid part of the body contents which are not particularly interesting. Better success may be had in mounting first- and small second-stage larvae by mounting them in a bit of the host egg contents. By moving the cover-slip about, the larva can be moved into such a position that it can be easily seen.

The larvae were mounted from water in a gum arabic solution made up as follows:

Materials

Glycerine	20 cc.	Gum Arabic	40 gr.
Water	50 cc.	Chloral Hydrate	50 gr.

When the gum is dissolved in water, dissolve the chloral hydrate in this, add the glycerine and filter. Do not mount specimens from alcohol but wash them first in water and remove from water to the slide.

The Egg of *T. gerriphagus* (Marchal)

The egg is ovoid in shape with a micropyle that is about the same length as the egg itself and a fifth as wide. The total length of an ovum dissected was about .228 mm. and the width .059 mm. at the widest part. Eggs found in the gerrid eggs measured .15 mm. in length and .038 mm. in width. These particular eggs had lost their chorion and micropyles when removed from the host egg contents. In the host egg they are placed at right angles to the median longitudinal axis with the micropyle pointing toward the point in the chorion where the ovipositor entered. It is usually so placed that either end is about equidistant from the chorion of the egg of the host. Ova dissected were for the most part almost transparent with a faint tinge of white over the chorion. Eggs found in the host egg have the contents around the center greyish-white and the outside tinged with a yellowish color.

Number of Eggs in Host Egg

Usually several eggs are laid in a single gerrid egg. Several females will lay at different times in the same egg. The greatest number known to have been laid in one egg is four. Three is the usual number.

The Larva

The presence of the larva in the host is known by the undulating movement that Marchal mentions. Henriksen[20] says that the larva of *Anagrus brocheri* Schulz, which lives under similar conditions, keeps the contents of the host egg stirred up by turning and bending in different directions. We were never able to locate the larva of *T. gerriphagus* when it had the host egg contents in a turmoil. The first stage larva no doubt can keep the contents stirred by whipping about with the row of spines around the abdomen. The second stage might keep them stirred in the same way. We are at loss to explain how the third form can keep the contents agitated.

What was apparently the center of the disturbance was marked usually by a thin, bubble-like ring that moved back and forth through the contents of the host egg. If the oscillating movement was regular, it disappeared for an instant when the end of the egg was reached, appearing again almost immediately and moving back to the opposite end, and here disappearing and reappearing as before. At times two such rings appeared simultaneously at both ends of the host egg. The second ring usually met the first one somewhere near the middle of the host egg where it disappeared while the first ring continued. We can offer no explanation for the appearance and disappearance of the rings.

The appearance and disappearance of the ring is sometimes regular and at others irregular. When irregular the time for the ring to pass from one end of the egg to the other is lengthened. At some periods the ring was not present but the back and forth flow of the contents continued. At other times no movement was seen. The following notes were taken on the irregular movements of full-grown larvae almost ready to pupate. The time is the number of seconds that elapsed between the disappearance and appearance of the oscillating movements.

Larva No. 1.

First day.

15 seconds	Continuous oscillating movements for
5 seconds	15 seconds
10 seconds	5 seconds
10 seconds	6 seconds
8 seconds	8 seconds
12 seconds	4 seconds
5 seconds	5 seconds

Second day.

The oscillating movement was continuous without the irregular lapses between the disappearance and appearance of the ring.

Third day.

Movement continuous but slower.

Fourth day.

No movement. Quiescent for pupation.

Larva No. 2.

First day.

1 minute	20 seconds
40 seconds	16 seconds
20 seconds	12 seconds
20 seconds	25 seconds
25 seconds	15 seconds

Second day.

Movement still irregular.

Third day.

Movements regular.

Counts were made of the number of movements appearing in a half hour when the motion was continuous.

Larva No. 3—73 movements in 30 minutes.
Larva No. 4—65 movements in 30 minutes.
Larva No. 5—68 movements in 30 minutes.
Larva No. 6—70 movements in 30 minutes.
Larva No. 7—70 movements in 30 minutes.

The First Larval Stage. (Plate IV, fig. 1.)

Three distinct stages of the larva are found. The first stage measures from .10 mm. to .16 mm. in length. Some of the larger larvae of this stage measure .158 mm. from the dorsal side of the abdomen to the tip of the caudal spine; the cephalothoracic region measures about .066 mm. from the dorsal to the ventral side. The general color of this stage and the second stage is a grayish-white, the same color as the contents of the gerrid eggs.

The newly hatched larva is divided into three regions. The head region is the largest of the three. At the apex on the ventral side a pair of flattened, curved oral hooks are found. They are .017 mm. in length from the tip to the base. Across the base the width is about .007 mm. Just below the oral hooks is a chitinized, bill-like labium. The oral hooks can be moved about by the larva and can be crossed. The labium does not seem capable of such movement.

After the larva begins to feed the abdomen becomes more and more distended until it is larger than the head and thoracic regions. The thoracic region seems to fuse with the head region. A deep constriction now marks the cephalothoracic region from the abdominal. On the dorsal and lateral sides of the abdomen is a row of flat spines. These spines are placed close together at regular intervals. They are .017 mm. in length. As suggested before their probable function is to propel the larva about through the egg contents. At the caudal end of the abdomen is the caudal horn ("la corne caudale") that Marchal mentions. This is the appendage that possesses the spine that he was unable to find. The total length of the horn is about .099 mm. The tip, from the spine to the point, is rather slender, being between a third and a fourth as wide as the basal portion. As there is not much difference in the size of the larvae of this stadium, it is probable that this stage extends over only a short period.

The Second Larval Stage. (Plates IV and V.)

The smallest second stage larva found measured .184 mm. in length and .121 mm. in width. The largest one found was .75 mm. in length and .50 mm. in width. The cephalothoracic region is no longer distinctly marked by a deep constriction. The general shape is ovoid for most specimens.

Lying at a slightly sloping angle on the dorsal side of the cephalic region are two plate-like thickenings of the skin. These are each divided into a large oval lobe and a small more or less triangle shaped lobe having two sharp angles and a rounded angle. The two small lobes lie at the dorso-cephalic apex of the body. These details are not always distinct and cannot be found in many specimens. Just between and a little beneath the rounded angles are the oral hooks on the ventral surface. These measure from .038 mm. to .040 mm. in length and from .019 mm. to .020 mm. in width at the bases. The labrum is a short flap-like structure extending between the bases of the oral hooks. It has not been found in the other stages. The beak-like labium resembles that of the first stage, differing principally in being a little larger and a little broader. It is found in the same position beneath the oral hooks. As in the first stage, the oral hooks can be crossed and moved about but the labium seems to be stationary.

The spines on the abdomen are not any larger than those of the first stage. They have, however, a different arrangement. Instead of being spaced one by one at regular intervals, they are arranged in scattered groups of five or six.

Only a stump of a caudal horn is left. This is about the same size as the spine on the caudal horn of the first stage. It is placed on the median line of the ventral side, distad to the tip of the abdomen. Instead of curving upward as the caudal horn of the first stage, it curves downward.

It was found by a study of the material at hand that several larvae are usually present in one egg at the same time and that the first and second stages are cannibalistic. All three stages have been found together in the same egg. The first stage was found fastened to the second or third stage larva (Plate IV, fig. 6), usually at the caudal end of the body. The larvae hold on by piercing the thick skin with the oral hooks and labium and by thrusting the caudal horn through the skin. They live upon the body contents of the attacked larva. As more than one larva is almost always found in the gerrid egg where a first stage is present, it is believed that the first stage larva is almost wholly cannibalistic. However, if no other larvae are present, it will probably feed upon the yolk disclets.

The second stage has been found feeding upon all stages. The first larval stage and the young larvae of the second stage are held clutched between the oral hooks and the labium. Sometimes the oral hooks pierce through the skin and sometimes they do not. We have slides showing the crumpled larval skins of the first stage between the oral hooks and with the labium fastened in them. The larvae have been squeezed dry of their contents. When the larva is larger than the attacking larva, the stump of a caudal horn is also fastened in the attacked larva's skin. Where there are not enough larvae in the egg to complete one larva's growth, the last larva completes his growth by feeding upon the gerrid egg contents.

The Third Stage. (Plate IV, fig. 5.)

The smallest third stage larva found measured .813 mm. in length and .40 mm. in width. Larger larvae that were in the prepupal stage measured up to 1.375 mm. by .625 mm. The length is somewhat longer than that of the pupa.

This stage differs very much from the first two stages. The body is elongate-ovate with the cephalic region indistinctly marked and not appearing to be any larger than that of the second stage. The cephalic region with the oral hooks appear to have migrated somewhat caudad of their second stage position. The oral hooks are very much reduced in size, being very slender and thread-like with broad bases. As compared with the second stage they are reduced in length and point cephalad instead of caudad, as in the first two stages. In the larvae measured their length was between .022 mm. and .033 mm. The width at the base was about .006 mm. They are of an orange-yellow color. The labium is not evident and the spines around the abdomen are also lacking, as is the caudal horn. Probably not much feeding is done in this stage.

The Prepupal and Pupal Stages

Almost all the third stage larvae that were dissected were in the prepupal stage. Probably this stage is as long or longer than the third larval stage. The transition from the prepupal to the pupal stage is not marked by a sudden sloughing off of the larval skin. Sometimes the skin does not break until the insect is ready to emerge. It usually, gradually disintegrates until it appears as a yellowish-white colored, thin blanket of pressed material covering the pupa. In most pupae it breaks up at this stage and collects along the ventral region around the legs and wings where it undergoes further disintegration.

Congested masses often appear in the thoracic and abdominal regions of the prepupal stage. Later in the pupa they become more compact and appear only in the abdominal region. Here there may be one or two masses of various shapes. Some are cigar-shaped, pear-shaped, cone-shaped, oval-shaped with a constriction in the center and various other forms. In live material they have been observed to change their shape from day to day. In older pupae they break up into small granules. This is waste material that is defecated by the adult.

The fresh pupa is of a lemon-yellow color. At first the compound eyes and ocelli are of the same color but as the pupa ages they first turn pinkish-brown, then a reddish-brown and finally a very dark brown. After the eyes are dark colored, a black pigmentation of the other parts of the body becomes noticeable. At this time the sutures of the abdomen appear. When the pupa has become fully pigmented it is of a jet black color, the same color as the adults.

The pupae fill the host eggs quite snugly. Usually they are found lying on their dorsal side. When in this position and when the time for emergence comes, they probably make a full half turn so that the exit hole is cut through the surface of the chorion opposite the side glued to the leaf surface. Some individuals are found lying on their sides. Probably these do not make a turn before cutting through the chorion, but cut it through the side of the egg. Oftentimes eggs are found with the exit hole cut through the side.

Length of Pupal Stage

On July 30, 1926, four eggs that contained pupaing larvae were isolated. On the 31st the new pupae could be seen. The red eye spots appeared on the 2nd of August and by the 11th the shining jet black color was fully developed. The adults emerged on the 15th of August, making the pupal stage fifteen days long.

Size of the Pupae and Adults

The following data were obtained from specimens at hand:

Measurements of Pupa in the Larval Skin

	Total Length	Width of Abdomen
No. 1	.888 mm.	.325 mm.
2	.888 mm.	.325 mm.
3	.888 mm.	.325 mm.
4	.937 mm.	.450 mm.
5	.937 mm.	.450 mm.
6	1.000 mm.	.450 mm.
7	1.000 mm.	.450 mm.

Measurements of Pupae with Colored Eyes

(Pupa in larval skin)

8	.95 mm.	.25 mm
9	1.00 mm.	.475 mm.
10	1.00 mm.	.34 mm.
11	1.00 mm.	.45 mm.
12	1.00 mm.	.45 mm.

Measurements of Partially Pigmented Specimens

(Larval skin partially disintegrated)

13	1.00 mm.	.35 mm.
14	1.00 mm.	.35 mm.
15	1.00 mm.	.35 mm.
16	1.00 mm.	.35 mm.

Measurements of Wholly Pigmented Pupae

(Some specimens almost covered with disintegrated material, others having it collected along the ventral region)

17	1.00 mm.	.26 mm.
18	1.00 mm.	.26 mm.
19	1.00 mm.	.27 mm.
20	1.00 mm.	.27 mm.

Measurements of Adults

21	1.00 mm.	.25 mm.
22	1.00 mm.	.25 mm.
23	1.00 mm.	.26 mm.
24	1.00 mm.	.26 mm.
25	1.00 mm.	.27 mm.
26	1.00 mm.	.29 mm.

We wish to call attention to the buttonhole-like slits that are found in the thoracic and abdominal regions of the pupae and adults. In the thoracic region series of short slits are found along the margin of the sutures. Longitudinal slits are found in the second and third abdominal segments. Nothing has been discovered concerning their function.

Per Cent of Parasitism

Parasitism was very high in *Trepobates* eggs but only about a third as high in *Gerris* eggs. This is a peculiar fact when it is taken into consideration that *Trepobates* eggs are covered with gelatine, apparently making oviposition in these eggs more difficult than in *Gerris* eggs. Observations show that the female parasites do have difficulty in locating the egg in the gelatinous matrix. *Trepobates* eggs were found on the same leaves with *Gerris* eggs but the parasite seemed to exhibit a marked preference for the *Trepobates* eggs.

In the material at hand there was a parasitism of 23.9 per cent for 3,017 *Gerris* eggs, while for *Trepobates* eggs it was 72.5 per cent for 917 eggs. There were 128 rows of *Gerris* eggs. Ten of these rows were parasitized 100 per cent and 10 were parasitized 70 per cent or over. Only 17.8 per cent were parasitized 70 per cent or over. Out of the 47 rows of *Trepobates* eggs, 12 were parasitized 100 per cent and 11, 70 per cent or more.

PARASITISM OF GERRIDAE EGGS BY TIPHODYTES GERRIPHAGUS (M.)
(*Gerris* Eggs)

Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized	Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized
1	34	14	41.1	33	18	5	27.7
2	44	14	31.8	34	20	1	5.0
3	33	12	36.3	35	22	11	50.0
4	7	0	00.0	36	26	6	23.0
5	7	2	28.5	37	42	0	00.0
6	12	0	00.0	38	28	0	00.0
7	10	2	20.0	39	12	2	16.6
8	9	0	00.0	40	8	4	50.0
9	45	0	00.0	41	28	6	21.4
10	7	5	71.4	42	10	10	100.0
11	25	0	00.0	43	15	1	6.6
12	12	4	33.3	44	100	0	00.0
13	12	1	8.3	45	26	6	23.0
14	25	16	64.0	46	30	9	30.0
15	20	1	4.0	47	10	10	100.0
16	18	1	5.5	48	11	9	81.8
17	8	4	50.0	49	18	6	33.3
18	7	1	14.2	50	8	4	50.0
19	24	3	12.5	51	14	7	50.0
20	30	5	16.6	52	21	9	43.8
21	21	2	9.5	53	14	4	28.5
22	20	20	100.0	54	6	6	100.0
23	16	4	25.0	55	18	4	22.2
24	40	0	00.0	56	21	1	4.7
25	50	0	00.0	57	18	4	22.2
26	6	6	100.0	58	14	4	28.5
27	12	1	8.0	59	8	5	62.5
28	19	2	10.5	60	26	0	00.0
29	24	2	8.3	61	20	2	10.0
30	30	4	13.3	62	10	1	10.0
31	10	6	60.0	63	20	8	40.0
32	24	12	50.0	64	40	0	00.0

Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized	Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized
65	20	1	5.0	95	5	5	100.0
66	45	0	00.0	96	14	2	14.2
67	24	2	8.3	97	24	12	50.0
68	22	10	45.4	98	17	15	88.2
69	14	2	14.2	99	10	4	40.0
70	20	1	5.0	100	18	18	100.0
71	40	4	10.0	101	28	7	25.0
72	30	2	6.6	102	32	3	9.3
73	15	15	100.0	103	15	12	80.0
74	20	4	20.0	104	18	3	16.6
75	100	0	00.0	105	43	2	4.6
76	12	3	25.0	106	32	10	31.2
77	20	8	40.0	107	67	14	20.8
78	20	6	30.0	108	5	2	40.0
79	15	3	25.0	109	24	22	91.6
80	24	3	12.5	110	10	9	90.0
81	18	9	50.0	111	15	5	33.3
82	21	7	33.3	112	14	6	42.8
83	16	2	12.5	113	16	4	25.0
84	60	15	25.0	114	100	0	00.0
85	75	0	00.0	115	15	5	33.3
86	100	0	100.0	116	38	36	94.7
87	10	0	00.0	117	20	1	5.0
88	42	2	4.7	118	30	10	33.3
89	21	3	14.2	119	15	15	100.0
90	14	6	42.8	120	68	5	7.3
91	14	4	35.7	121	96	8	8.3
90	36	4	11.1	122	54	16	30.8
91	12	1	18.2	123	24	0	00.0
92	14	1	7.1	124	20	19	95.0
93	10	9	90.0	125	22	15	68.1
94	36	36	100.0	126	20	0	00.0

(*Trepobates* Eggs)

Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized	Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized
1	18	18	100.0	7	20	19	95.0
2	18	16	88.8	8	18	18	100.0
3	16	8	50.0	9	20	2	10.0
4	6	6	100.0	10	28	14	33.3
5	21	19	90.4	11	60	60	90.9
6	60	60	100.0	12	10	5	50.0

Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized	Row No.	No. Eggs	No. Parasitized	Per Cent Parasitized
13	48	35	72.9	32	32	30	93.0
14	36	26	72.2	33	20	8	40.0
15	14	12	85.7	34	14	14	100.0
16	22	22	100.0	35	14	4	28.5
17	7	4	59.1	36	10	0	00.0
18	20	20	100.0	37	20	16	80.0
19	10	10	100.0	38	32	32	100.0
20	22	15	68.1	39	8	8	100.0
21	18	0	00.0	40	20	18	90.0
22	9	3	33.3	41	22	3	13.6
24	16	0	00.0	42	10	6	60.0
25	8	2	25.0	43	14	7	50.0
26	8	4	50.0	44	14	14	100.0
27	20	1	5.0	45	18	16	88.8
28	6	2	33.3	46	12	0	00.0
29	8	4	50.0	47	8	4	50.0
30	12	1	8.3	48	10	2	20.0
31	24	6	25.8				

In some of the above counts more than one row of eggs is included in the count.

Summary

Tiphodytes gerriphagus (Marchal) lays its eggs in *Gerris* eggs in two ways. One by going under the water to reach them, and the other by backing over the edge of the lily pad and reaching them with the abdomen and ovipositor. The larvae pass through three stages. The first two stages are cannibalistic and also feed upon yolk disclets of the gerrid egg. Both the first and second stages make use of their oral hooks, bill-like labium, and caudal hook or horn, to hold on to the attacked larvae while feeding upon them. The row of flat spines around the abdomen is more than likely used to propel the larvae about through the contents of the gerrid egg. The third stage is elongate-ovate and does not resemble the first two forms. It lacks the bill-like labium, the spines on the abdomen, and the caudal hook. The oral hooks are reduced in size. Probably most of this stage is really the prepupal stage. The pupal stage is 15 days long. A preference is shown for *Trepobates* eggs.

Sialis infumata Newm.

Length of Adult Stage

On June 20th and 21st, 1926, great numbers of this insect swarmed along the shores of Douglas Lake, Michigan. The males seemed to be at this time in greater numbers than the females. On the 22nd the numbers of the females seemed to be greater than the males. At this time a great many eggs and pupae were collected, the pupae being found under logs, sticks, and other debris along the beach. The pupae were dropped in a live jar and when the laboratory was reached it was found that fully half the pupae collected had transformed to adults. All but one or two of this number were females. The following notes were kept on the abundance along the shore:

June 20—Large numbers of males.
21—Large numbers of males.
22—Large numbers of males and females.
24—Abundance of *S. infumata* continues.
27—Abundance of *S. infumata* continues.
July 1—Abundance of *S. infumata* continues.
2—Abundance of *S. infumata* continues.
5—Numbers of *S. infumata* noticeably decreased.
10—Very few *S. infumata* adults along beach.
14—Two females found laying in a sheltered bay, the only two that were seen during the day. The last ones that were seen during the rest of the season.

Oviposition

Davis' observations were that they prefer to lay eggs "on undersides of boat landings, on vertical sides of bridges and on stones projecting above creek or lake waters. They do not seem to select twigs of trees or shrubs when the above objects are accessible. The eggs are deposited on objects within the limits of running water."

At Douglas Lake the most common object on which the eggs were found was *Scirpus* stalks, which were standing in water from six inches to a foot and a half in depth. No eggs were found on *Scirpus* that was in deeper water. Eggs were also laid on the twigs of pussy-willow and other plants that over-hung the water's edge. No eggs were found on the boat-landings around the lake. Searches were made for eggs around the beach pools and on vegetation a short ways back from the water's edge but egg masses were found only once, these being on *Scirpus* that was eight or ten feet back from the water. The egg laying activities of the *Sialis* seemed to be confined to the southeast end of the lake, which was the point toward which the wind usually blew. No eggs were found around other parts of the lake.

On calm days great numbers of females could be found ovipositing, while on days when a strong wind was blowing, they were found under cover in the shrubbery along the shore. Sunshine did not seem to affect their laying activities, as they were found depositing eggs on cloudy as well as on sunny days.

After alighting on a stem the female usually runs rapidly about over the plant, searching for other egg masses. It seems to be easier for her to use the mass of another female as a marker for the one she lays than to start a new one. Davis gives a short description of oviposition as follows: ''The female deposits an entire row of from ten to twenty eggs and then begins another row . . . she now moves backward over the mass to reach the place for the succeeding row; thus her wings and body cover the mass until it is laid.''

The writer is able to give a more detailed account of the laying. When an egg is about to be laid, the lips of the valves of the ovipositor fit tightly against an egg or eggs already laid. Then the tip of the abdomen is lowered until the fine hairs on the caudal tip of it touch the surface on which the egg is to be deposited. The valves open slightly and the egg comes down. It is covered with a sticky, brown cement that turns darker brown upon drying. Some females secrete a cement that is much lighter in color than that of other females. Where several females lay on the same mass it is possible to tell precisely, several days after the eggs are laid, one female's mass from another by the color of the eggs. Upon touching the plant's surface the tip of the egg is immediately cemented to it. The abdomen is raised with a forward swing toward the egg or eggs opposite the one being deposited, thus setting the newly laid egg against its neighbors. The cement substance becomes dry immediately and thus the egg is cemented firmly to the leaf and to the eggs adjoining it.

The order followed in oviposition was as follows: The egg mass was composed of rows from 12 to 25 eggs long. A row was usually begun at the left end and the eggs were laid in one, two, three, four order toward the right. From four to six eggs were laid. When the fifth or sixth egg had been laid, the opposite end of the row was begun and five or six more were laid. Then the female returned to the unfinished left end and deposited five or six more eggs. This left to right and right to left action was continued until the row was finished at the center. Sometimes one or two more eggs were laid at the center for a new row. Then the left end of the new row was begun.

Laying was continuous until half the mass was complete, and then there was a pause of forty-five or fifty seconds, after which laying was resumed. Whether all females make this pause is not known, but all that were observed did. During the whole period of oviposition the female is not easily disturbed and it was possible to pluck the plant she was on and carry it about without disturbing her. When a mass of 300 or 400 eggs was complete the female flew away immediately.

The data for the following egg laying rates were secured from five females:

Female No. 1—67 eggs deposited in 5 minutes.
21 eggs deposited in 2 minutes.
64 eggs deposited in 5 minutes.

Female No. 2—60 eggs deposited in 5 minutes.
61 eggs deposited in 5 minutes.
23 eggs deposited in 2 minutes.

Female No. 3—60 eggs deposited in 7½ minutes.
35 eggs deposited in 3 minutes.

Female No. 4—60 eggs deposited in 6½ minutes.
60 eggs deposited in 6 minutes.

Female No. 5—58 eggs deposited in 5½ minutes.
60 eggs deposited in 6 minutes.

Time of Oviposition

No females were ever found laying during the morning or extremely late afternoon. Ovipositing females were found usually from midday until about four or five o'clock in the afternoon.

Notes on a Kansas Brood of Sialis infumata Newm.

At Lawrence, Kansas, further observations were made on the laying habits of a brood that has established itself at a reservoir on the campus of the University of Kansas. This place is popularly known as Potter's Lake.

The first insects found were males that appeared on April 9, 1927. The only other record known of this colony is from a series of 12 males and 45 females taken by Mr. Robert Guntert on April

14, 1922. As noted with the brood at Douglas Lake, Michigan, the males appeared two days before the females. The first eggs were found on April 12, 1927, one day after the first appearance of the females. Egg laying extended over a period of seven or eight days. On one day no eggs were laid because of a downpour of rain and on another because of extreme chilliness. The manner of oviposition and the length of time required to lay the eggs were the same as at Douglas Lake. The last adults were females seen on April 23, 1927.

Incubation

The incubation period of *Sialis* eggs at Douglas Lake covered a period of from seven to ten days. The daily average temperature was 64° F. In Kansas the period was from 9 to 15 days. The average daily temperature from April 9 to 23, 1927, was 57.2° F. Most of the larvae hatched on the 26th and 27th of April. The eggs laid on the 12th of April did not hatch until the 27th. A few masses hatched a little later.

Parasitism

No parasites emerged from the *Sialis* eggs taken in Kansas. *Trichogramma minutum* Riley has been reported in the vicinity of Lawrence.

Copulation of Sialis infumata Newm.

Several pairs were observed copulating and in each instance the procedure was the same. The female stood motionless, her head usually pointing toward the tip of the stem upon which she rested. The male approached from behind and crawled under the wings of the female until his head was even with her abdomen. He then curled his abdomen over the left side of his head, pushing aside his left pair of wings. As soon as the body of the male was in the shape of a letter U the tip of his abdomen came in contact with that of the female and copulation was completed. The male remained in this position for five or ten seconds, then straightened out and started to crawl away. Usually he came back and tried to copulate with the female a second time. In other instances the female refused to copulate and crawled rapidly away from the male. Several times as many as three males were seen to be following one female and many times two males followed the same female, but none seemed to be able to copulate with her on such occasions.

Hatching Dates of Aquatic Insect Eggs

The following hatching dates are recorded from material that was being watched for parasitism at the Douglas Lake Biological

Station of the University of Michigan. Large numbers of eggs were kept in a single cage.

Insect	No. Cages	Cage Date	Hatching Date
Ranatra	10	7/1/26	7/11 to 17/26
Galerucella	2	7/1/26	7/7/26
	2	7/4/26	7/7/26
Donacia	4	7/4/26	7/7/26
	3	7/5/26	7/17/26
	1	7/6/26	No emergence
Hydrophilus	2	7/4/26	7/7/26
	2	7/5/26	7/9/26
	2	7/8/26	7/17/26
Bothrothus	2	7/8/26	7/17/26
Notonectidae	4	7/8/26	7/24/26
	2	7/8/26	8/4/26
Zygoptera	2	7/8/26	7/24/26
	2	7/8/26	8/4/26
	1	7/26/26	No emergence
Anisoptera	2	7/8/26	No emergence
Gyrinidae	2	7/8/26	7/9/26
	4	7/22/26	7/22/26
	2	7/26/26	7/30/26
	2	7/4/26	7/17/26
Triaenodes	10	7/1/26	7/5/26
	2	7/1/26	7/7/26
Gerridae	6	7/22/26	7/24/26
	10	7/26/26	7/29/26
	2	7/26/26	7/30/26
	6	7/30/26	8/9/26
	1	8/2/26	8/10/26

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(For *Tiphodytes gerriphagus* (Marchal))

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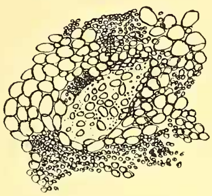
PLATE III

Fig. 1. An egg of *Trichogramma minutum* Riley among the yolk disclets of the host egg, *Sialis infumata* Newm.
Fig. 2. Eggs of *T. minutum* R.
Fig. 3. Antenna of abberrant form of *T. minutum* Riley.
Fig. 4. Emergence holes (round holes) of *T. minutum* Riley and hatching slits of *S. infumata* N.
Fig. 5. Gatenby's fig. 2.
Fig. 6. Gatenby's fig. 8.
Fig. 7. Gatenby's fig. 3.
Fig. 8. *Trichogramma minutum* R. copulating.



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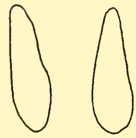

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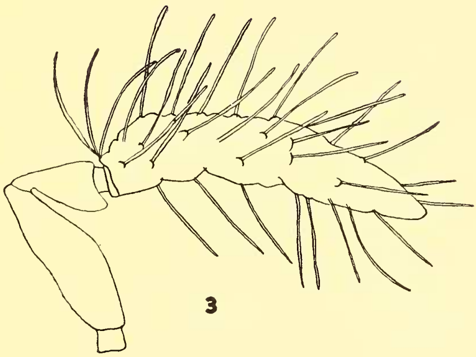

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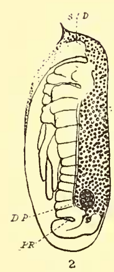

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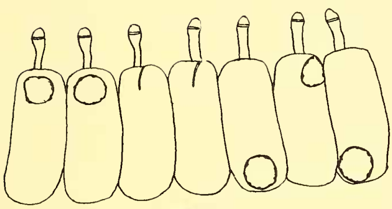

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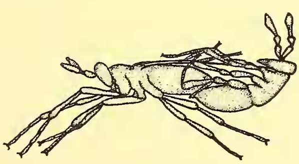

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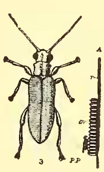

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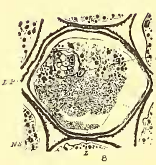

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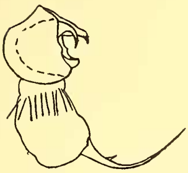
PLATE IV

Tiphodytes gerriphagus (Marchal)

Fig. 1. Newly hatched first instar larva.
Fig. 2. First instar almost ready to molt.
Fig. 3. Egg of *T. gerriphagus* (M.).
Fig. 4. Ventral view of second instar larva.
Fig. 5. Larger instar larva eating a smaller one.
Fig. 6. Third instar attacked by a first instar larva.



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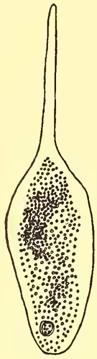

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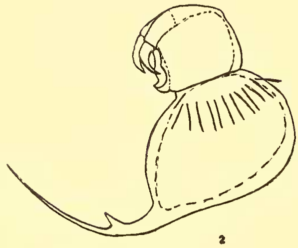

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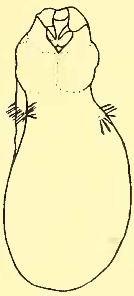

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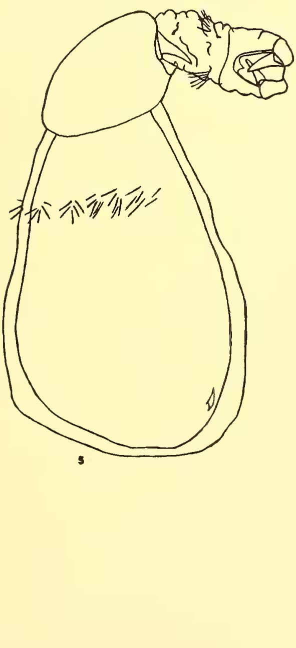

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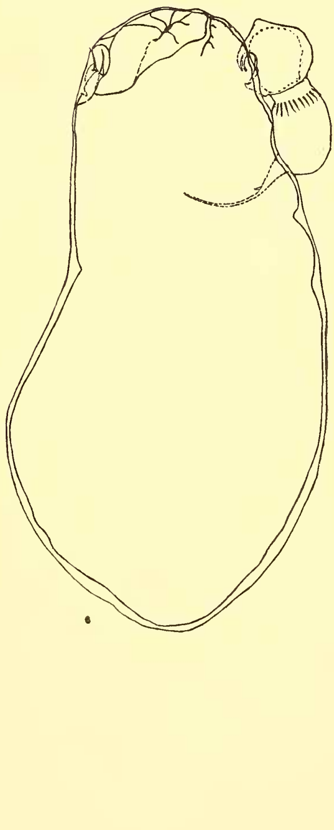

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PLATE V

Tiphodytes gerriphagus (Marchal)

Fig. 1. A dorsal-ventral view of the cephalic region of second instar larva.
Fig. 2. A non-typical second instar larva.
Fig. 3. Abdomen of male with about one-third of penis extruded.
Fig. 4. Lateral view of cephalic region of second instar larva.
Fig. 5. Abdomen of female with ovipositor extruded full length.
Fig. 6. Lateral-ventral view of second instar larva.